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*Biomedical and Related Life Support Aspects of the Soyuz 12 Mission*

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# Biomedical and Related Life Support Aspects of the Soyuz 12 Mission

Project Officer

[redacted]

## PRÉCIS

One objective of the Soyuz 12 mission, launched 27 September 1973, apparently was to determine whether modifications made to equipment and procedures following the catastrophic failure of the Soyuz 11 cabin pressurization system would alleviate the problems encountered in the earlier mission. All modifications appeared to serve their purposes, and no adverse biomedical effects attributable to the equipment were noted from [redacted] or published Soviet reports.

# BIOMEDICAL AND RELATED LIFE SUPPORT ASPECTS OF THE SOYUZ 12 MISSION

*Project Officer*

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June 1975

CENTRAL INTELLIGENCE AGENCY

DIRECTORATE OF SCIENCE AND TECHNOLOGY

OFFICE OF SCIENTIFIC INTELLIGENCE

# PREFACE

Piloted by physician-commander Lt. Col. Vasily Lazarev who was assisted by engineer-cosmonaut Oleg Makarov, Soyuz 12 began a 2-day, earth-orbital flight on 27 September 1973. This was the first space mission for both men. The Soyuz 12 mission marked the reinitiation of Soviet manned space flights after a 27-month hiatus following the fatal accident aboard the Soyuz 11 spacecraft. During the mission the crew checked the integrity of the pressurization system and tested new space suits carried as additional protection against decompression (the cause of the Soyuz 11 deaths). They continued with tests of the docking mechanism and conducted a variety of maneuvering and attitude control operations. The Soviets reported that extensive scientific experiments in photography, relating to an earth resources survey, also were undertaken. On 29 September, Soyuz 12 landed safely in the normal recovery area. The improved Soyuz model tested apparently is intended for joint operations with an advanced space station rather than for the Apollo-Soyuz Test Project (ASTP).

Information [redacted] was compared with published Soviet medical data for the Soyuz 12 flight to determine the status of cosmonaut health throughout the mission and to make an assessment of the adequacy of the life support system. Data on Soviet biomedical monitoring techniques for the Soyuz 12 are given in an appendix.

[redacted] This report was prepared by the Office of Scientific Intelligence and coordinated within CIA. The cutoff date for information is August 1974, but information through April 1975 does not change the conclusions.

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# BIOMEDICAL AND RELATED LIFE SUPPORT ASPECTS OF THE SOYUZ 12 MISSION

## PROBLEM

To evaluate biomedical and related life-support aspects of the Soyuz 12 mission.

## SUMMARY AND CONCLUSIONS

One of the major objectives of the Soyuz 12 mission appears to have been to demonstrate the adequacy of design and procedural modifications made after the catastrophic loss of Soyuz 11 cabin pressurization during reentry. All modifications appeared to serve their purpose, and no adverse biomedical effects attributable to the equipment were noted from [redacted] published Soviet reports.

The environmental control system, which was similar to that in other Soyuz models, appeared to function satisfactorily while maintaining comfortable and safe atmospheric conditions throughout the mission. Space suits were worn by the crew during launch, on initial and final orbits, and during descent as additional protection against accidental loss of atmospheric pressure. The crew devoted much more time to checking hatch seal integrity than on previous missions. Soviet space authorities reported that the valve adjacent to the hatch seal had been redesigned.

Space suits appear to be indispensable to flight safety on future missions aboard this spacecraft. Since the Soyuz spacecraft is large enough to accommodate only two cosmonauts in pressure suits, prospects are good for continuation of the two-man crew configuration.

The Soyuz 12 pilot, Lt. Col. Vasily Lazarev, is a physician cosmonaut who had been rejected previously for space service on medical grounds. Lazarev experienced a notable but not life threatening cardiac episode during orbit 1; [redacted] The second crewman, Oleg Makarov, is a qualified flight engineer and had no medical problems. Both crewmen experienced relatively high heart rates during launch. Both cosmonauts reported a respiratory episode, occurring early in flight, in which both paradoxically experienced a desire to inhale deeply at a time when they felt that their chest cavities were overfilled. These symptoms apparently have not been experienced previously in either the US or Soviet space program and no explanation has been found for them. Spacecraft environmental parameters at the time do not indicate any external cause. The space suits apparently were not involved since they had been removed earlier.

The crew adjusted to weightless conditions but apparently experienced the usual vestibular problems noted on other flights. The cosmonauts' performance was at all times adequate to carry out their assigned tasks, although they reported that they were easily fatigued. After descent, readaptation to gravity appeared to be normal.

The choice of a physician and an engineer, both trained observers, as the crew for Soyuz 12 seems especially appropriate because this mission was the first flight test of space suits and engineering modifications incorporated to resolve vital environmental control problems. After a 27-month hiatus in Soviet manned space flights, the mission was crucial for reestablishing Soviet confidence in their capability for continuing manned space operations.

# DISCUSSION

## BIOMEDICAL ASPECTS

### Medical Activities

There is no evidence to suggest that any significant biomedical research tasks were undertaken during the 48-hour flight of Soyuz 12. Because the pilot-commander, Lt. Col. Vasily Lazarev, is also a physician, however, the Soviets made use of his capability for medical observations, termed "self-monitoring," not carried out on previous Soyuz flights (see figure 1). The only event thought to be new or significant was some respiration difficulty experienced by both crewmen that has never been previously reported by Soyuz cosmonauts.[1 2] In general, both men adjusted to the weightless conditions of flight but not without the usual vestibular and fluid distribution problems experienced by other cosmonauts during flight. The performance of the Soyuz 12 crew was at all times adequate to carry out assigned tasks, although both reported that they were easily fatigued. Postflight readaptation to gravity appeared to be normal.[2]

### Heart Rate

Both cosmonauts experienced some increase in heart rate in the early phases of the mission (see figure 2). During orbit 1, while the crewmen were still in space

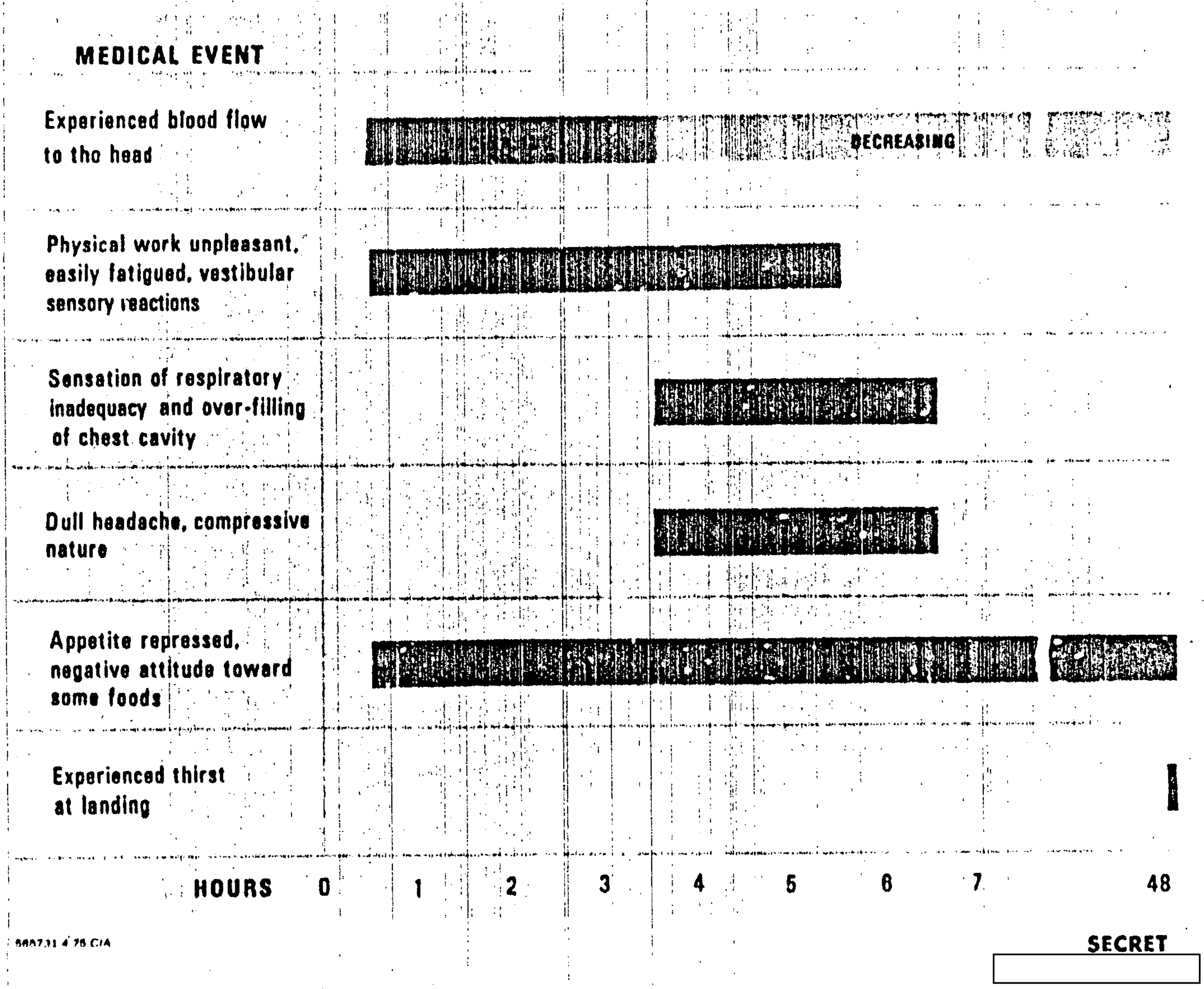
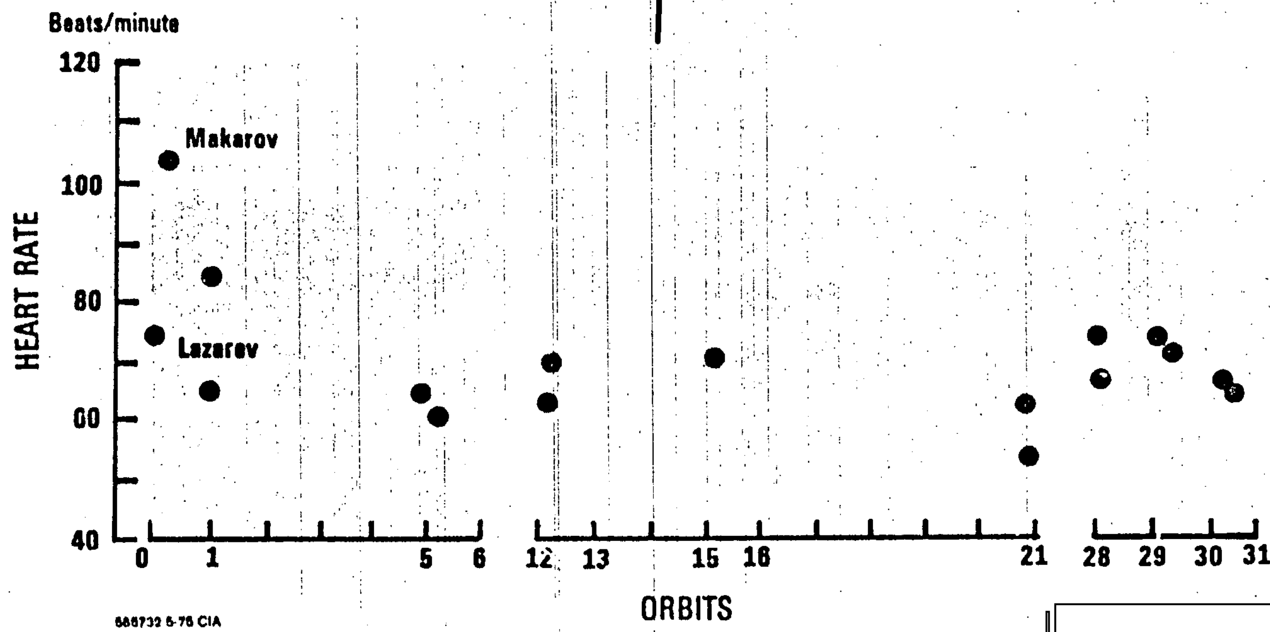



Figure 1. Soyuz 12 Physician-Pilot Observations of Crew Status




[redacted]

Figure 2. Heart Rates of Crew During the Mission

suits, Lazarev experienced cardiac arrhythmia which appears to have resulted from supraventricular ectopic beats, either atrial or junctional; post-ectopic overdrive was minimal. If the monitored arrhythmia is pathological in nature, it could probably be controlled by drugs such as propranolol hydrochloride, there is no indication that any drugs were administered in flight. Drugs could conceivably have been self-prescribed and administered by Lazarev as a physician, with or without consultation with Soviet medical officers on the ground.[1]

The runs of apparent supraventricular ectopic beats experienced by Lazarev are attributed to extracardial factors and not to myocardial pathology. Lazarev also reportedly experienced extrasystoles under physical load during ground training. Lazarev failed to pass the cosmonaut physical examination requirements twice before he was accepted. It is not known, however, what the medical grounds for rejection were.[2] [3]

During the four orbits after the episode of cardiac arrhythmia and during a large part of the total mission, both crewmen had their biomedical instrumentation unplugged. This would appear contrary to good biomedical procedure considering the cardiac episode of the pilot during orbit 1. Lazarev undoubtedly knew that he was experiencing tachycardia and conceivably could have unplugged his medical monitors purposefully and thus have prevented ground controllers from observing cardiac anomalies which might have been cause to shorten or abort the mission.

### Respiration

A Soviet report states that approximately three and one-half hours into the flight, the physician-cosmonaut Lazarev, and then the ship's engineer Makarov, noted a never-before-reported sensation—overfilling of the chest cavity—accompanied by a sensation of respiratory inadequacy. As expressed by the ship's commander, "I wanted to inhale well and take several breaths." The Soviets attributed this difficulty to sensations "associated with blood redistribution to the head and in the central region of the body."[2] [redacted] In plotting rate trends from available data, however, the rates never seem to be abnormally high in comparison with those from past flights (see figure 3).[4] [5] [redacted] It is likely that this difficulty was due to temporary pulmonary/vascular congestion (edema) induced by the weightless environment.

### Pre- and Postflight Examinations

Lazarev and Makarov underwent routine pre- and postflight physical examinations and tests for the 2-

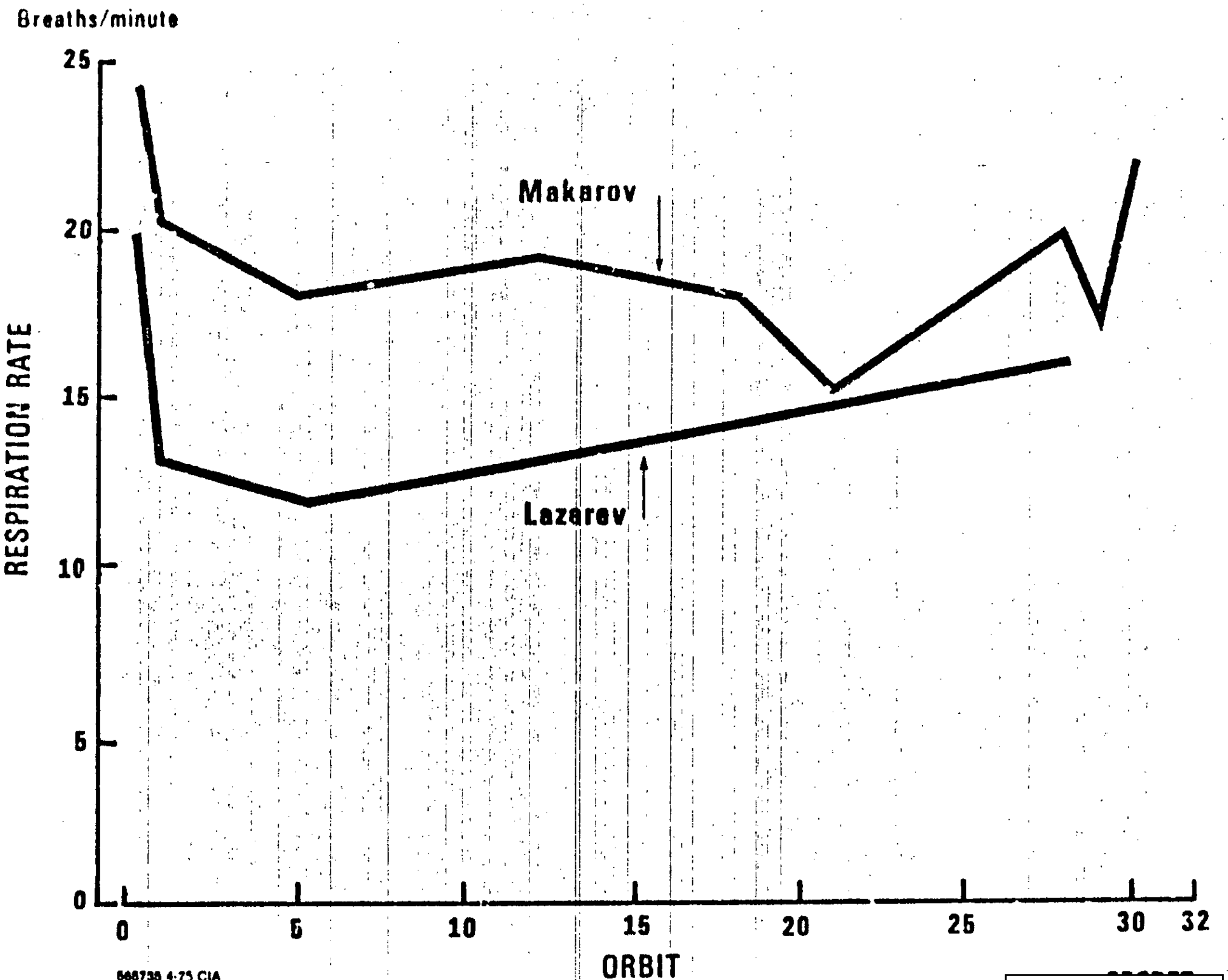



Figure 3. Pressure of Space Suits and Atmosphere in Soyuz 12

day mission.[2] According to the Soviet medical report, these medical examinations were conducted at the following intervals:

| Preflight | Postflight |
|---|---|
| 170 days | Upon landing |
| 150 days | 3-4 hours |
| 60 days | 16-18 hours |
| 25 days | 2 days |
| 5 days | 3 days |
| 3 days | 2 weeks |
| Flight day | |

A comparison of postflight results published by the Soviets with previously published Soviet data on other space flights reveals that postflight blood sodium levels of Soviet cosmonauts normally show an increase of 4 to 19 percent. Data on the Soyuz-12 crew, however, show decreases in blood sodium of 9 percent for one cosmonaut and 11 percent for the other. The crewmen also had a postflight decrease in blood osmolarity. Apparently, the Soyuz-12 crew was better hydrated in flight than crews of other space flights.

## LIFE SUPPORT ASPECTS

### Environmental Control System and Pressure Suits

The environmental control system (ECS) of Soyuz 12 appears to have been similar to those used on previous Soyuz flights. It is also similar to the ECS expected to be used aboard the Soyuz spacecraft for the ASTP mission. No obvious changes in ECS operations were apparent on Soyuz 12 from other Soyuz flights. USSR space authorities reported that the valve adjacent to the hatch seal had been redesigned following the Soyuz 11 failure.[6]

Major subsystems of the ECS include: (1) a "regeneration unit" which provides an exchange cycle for the respiration products of the crew by releasing oxygen and absorbing carbon dioxide and water vapor; (2) a temperature control system which transfers heat from habitable compartments to space by means of heat exchanges, liquid loops, and radiators; and (3) compressed air supplies which replenish atmospheric losses due to leakage. Air supply containers are installed in the descent module only.[6 7]

Pressure suits were worn by the crew during the launch and final descent phases of the mission. From a photograph of the Soyuz 12 crew in pressure suits (see figure 4), the pressure suits appear to be similar to the suit worn by Cosmonaut Leonov on Voskhod II in 1965. The external configuration of the helmet and the articulation of the arm and shoulder joints bear a very close resemblance to the Voskhod suit. Both the Voskhod and the Soyuz 12 suits were also articulated at the waist, hips, and knees, and while both suits appear similar there is insufficient detail in the picture to make a comparison of these features. The level of technology apparent from the shoulder joint configuration indicates that the pressurized Soyuz 12 suit probably imposes severe limitations on movement similar to that experienced by Leonov in the pressurized suit on Voskhod II.[8 9]

Since the Soyuz seating arrangement, and particularly the couch design, were predicated on a three-man crew dressed in lightweight flight clothing, there was not enough space to accommodate the normal crew wearing space suits. The size of the crew was reduced to two cosmonauts and available space was apportioned to provide sufficient volume for installing the suit control system near th crew.[10 11]

Critical ECS operations took pl s usual soon after orbital injection and again prior to descent and were performed without incident (see table 1). Lazarev and Makarov had donned their space suits before launch and wore them during powered flight and throughout insertion into orbit. During this time, the inner hatch was closed, sealing the crew in the cabin. The cabin ECS maintained normal atmospheric conditions. Since the orbital compartment was unoccupied during the period when the inner hatch was closed, the regeneration unit in the orbital module was not operated.[7]

The crew pressurized their suits (having vented them previously to the cabin atmosphere) for a period of about 10 minutes beginning at 1405Z during orbit 1, in preparation for entering the orbital module. While protected in this manner against the effects of accidental decompression, operations were initiated to test the orbital module outer hatch mechanism. When

Figure 4. Soyuz 12 Crew in Pressure Suits

**Table 1**

**Soyuz 12 Environmental Control Operations**

| Flight Phase | Date | Space Suits | Regeneration Unit: Descent Module | Regeneration Unit: Orbital Module | Inner Hatch |
|---|---|---|---|---|---|
| Launch............. | 27 Sep 73 | On, pressurized | On | Off | Closed, sealed |
| Orbit 1............. | 27 Sep 73 | Repressurized during 1405–1415Z; removed after 1415Z | Off at 1414Z | On at 1411Z | Opened at 1422Z |
| Orbit 28............ | 29 Sep 73 | On, pressurized during 0801–1813Z | On at 0740–0741Z | On | Closed, sealed at 0714Z |
| Retro and separation.. | 29 Sep 73 | On, pressurized | On | On | Closed, sealed |

that hatch appeared to be securely locked and sealed, the orbital module regeneration unit and related ECS components were activated and the inner hatch was opened without incident. The orbital compartment regeneration unit was activated and the cabin unit was shut down according to plan. The crew then depressurized and subsequently removed their space suits.

During orbit 28 on the last day of the mission, the cosmonauts prepared for reentry by switching on the cabin ECS (0740Z) and closing and sealing the inner hatch (0741Z). To check the hatch seal, pressure in the orbital module was reduced about 20 percent, but the regeneration unit was kept in operation. By 0813Z the crew had put on and pressurized their suits. [redacted]

ECS and suit operations throughout the mission appeared to be normal and satisfactory. There were no difficulties noted nor any evidence of hardware malfunctions. The extra protection provided by space suits during crucial flight operations appears to be important enough to have outweighed the disadvantages of reduced mobility from wearing the suits or of having to remove and stow them when not in use. For this reason, the Soviets are expected to continue providing space suits for cosmonaut crews of future Soyuz spacecraft.

## Atmospheric Conditions

Oxygen partial pressure increased gradually after launch on the Soyuz 12 flight, as it has during other Soyuz missions.[12] [13] Pressure reduction in the orbital module is known to have occurred in preparation for descent. Figure 5 shows that orbital-module pressure was reduced from about 830 mmHg to 670 mmHg during orbit 28 to check the integrity of the inner hatch seal. As usual for retro ignition, orbital-pressure was vented to zero preparatory to separation of the modules during descent.[7]

High-pressure conditions indicated for the descent module at the beginning and near the end of orbital flight are thought to be related to manifold pressure in the space suit system. These indications changed abruptly, which is characteristic of digital steps and suggestive of switching operations between two pressure vessels, such as between the cabin and the space suit manifold. The latter apparently was regulated at a pressure differential of about 0.28 atmospheres above module pressure. This differential pressure coincides with the minimum space suit pressure recorded during Leonov's EVA on Voskhod 2.[14] A minimum pressure of 0.28 atmospheres would be high enough to protect the crew in the event of cabin depressurization, yet low enough to prevent immobilization of the cosmonauts at normal descent-module pressure.

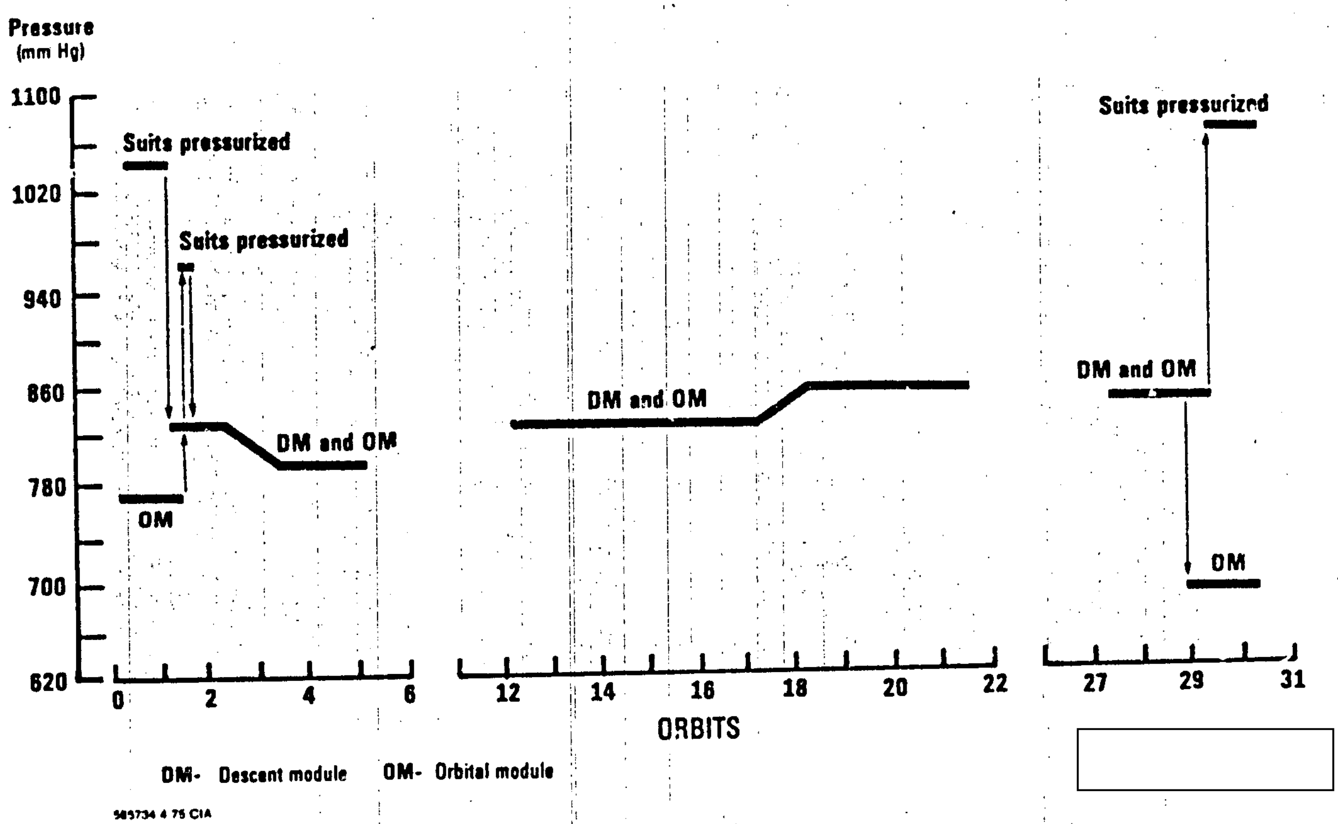



Figure 5. Trend of Crew Respiration Rates During the Mission

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## REFERENCES

The source references supporting this paper are identified in a list published separately. Copies of the list are available to authorized personnel and may be obtained from the originating office through regular channels. Requests for the list of references should include the publication number and date of this report.

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